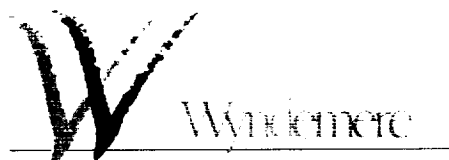


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ATTN: Accessioning Dept.

Software manual to accompany
final report for contract NAS2-14284

Air Traffic Complexity Measurement Environment (ACME)
Software User's Guide



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Appendices

- A: SAR Input File Format**
- B: RUNDMC Startup Files**
- C: More About PVM**
- D: Master Complexity Plot File**

1. Introduction

The Air Traffic Complexity Measurement Environment (ACME) consists of two major components, a complexity analysis tool and user interface. The complexity analysis tool (CAT) analyses complexity off-line, producing data files which may be examined interactively via the Complexity Data Analysis Tool (CDAT).

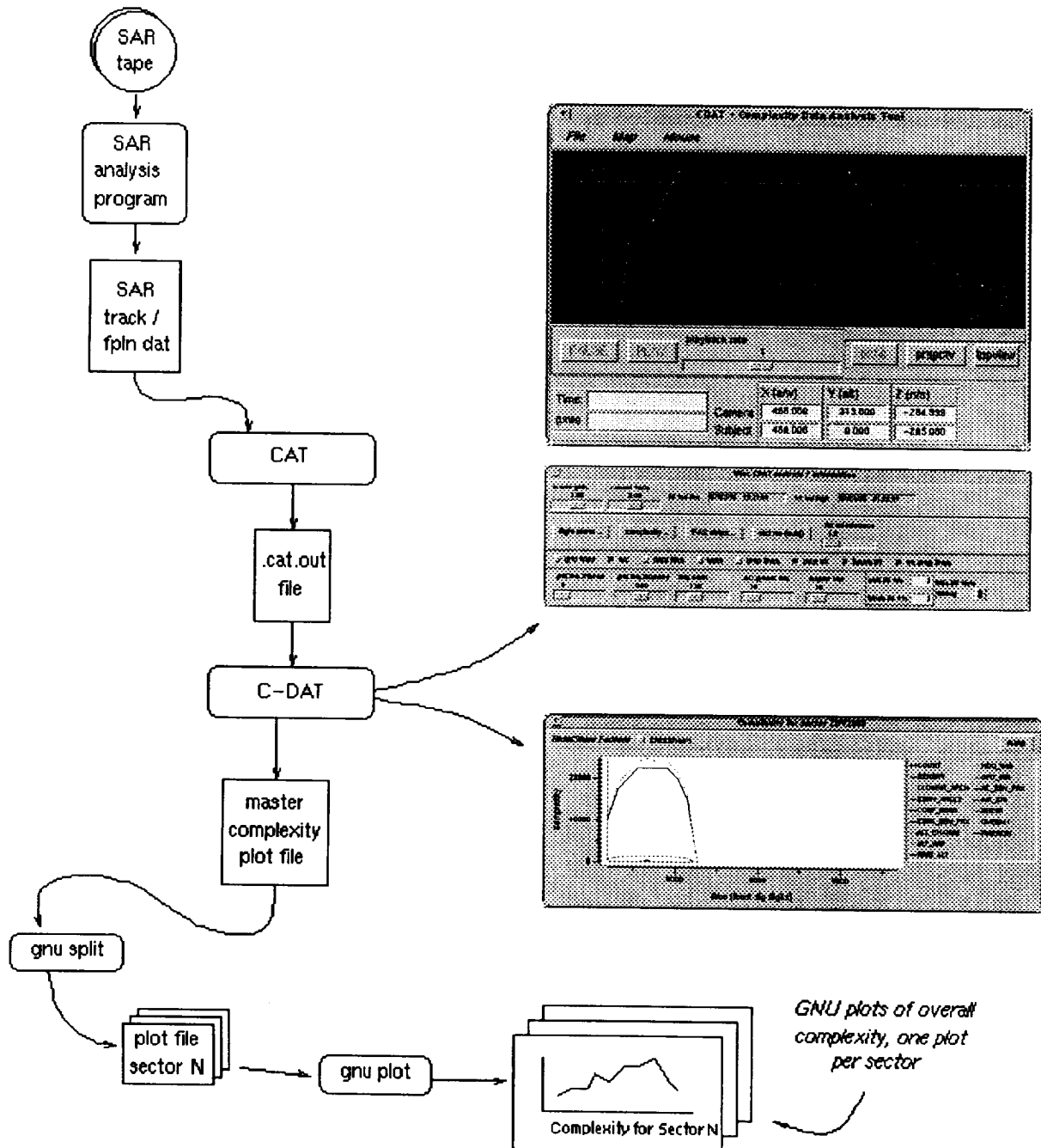
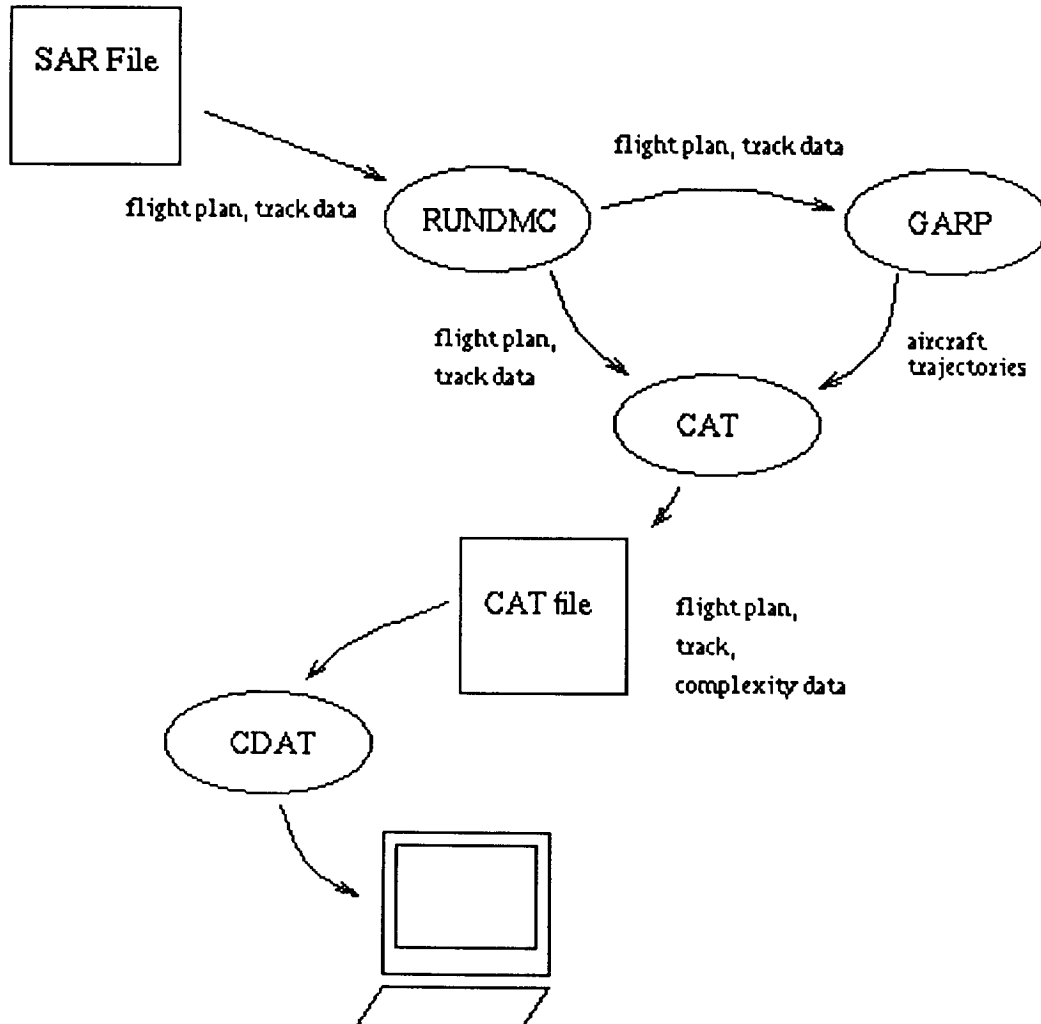


Figure 1-1 CAT / CDAT Overview

2. Complexity Analysis Tool (CAT)

2.1 Overview

The Complexity Analysis Tool is composed of three independently executing processes that communicate via PVM (Parallel Virtual Machine) and Unix sockets.



The Runtime Data Management and Control process (RUNDMC) extracts flight plan and track information from a SAR input file, and sends the information to GARP (Generate Aircraft Routes Process) and CAT (Complexity Analysis Task). GARP in turn generates aircraft trajectories, which are utilized by CAT to calculate sector complexity. CAT writes flight plan, track, and complexity data to an output file, which can be examined interactively using CDAT.

2.2 CAT Input

There are three types of CAT input files; system files, SAR input files, and RUNDMC startup files.

System files are read once during system initialization, and contain static information (e.g. data defining SIDs and STARs, preferred routes, aircraft characteristics, etc.). (see 3.2.1 System Files for more)

SAR input files are ASCII files containing flight plan and track data, and are typically created by running an extraction process on SAR recordings from Air Route Traffic Control Centers. SAR input files can also be created manually, provided they conform to the specified format. (see appendix A SAR Input File Format).

RUNDMC startup files specify such things as the names of the input and output files, and what complexity analysis mode(s) to use. A full explanation of the RUNDMC startup file is provided in Appendix B RUNDMC Startup Files.

2.3 Running CAT

To run CAT:

- Create or obtain a SAR input file. (Example SAR input files (named *.sar_out) have been provided in /direct/data/input.)
- Set up a RUNDMC startup file per the instructions found in Appendix B. (An example RUNDMC startup file has been provided in /direct/bin/SUN4SOL2 named *example_rundmc.startup*)
- Change to the directory containing the RUNDMC, CAT and GARP executables. (Provided the instructions specified in the ACME Software Installation and Porting Guide have been followed, this directory should be called

/direct/bin/<arch>

where <arch> is the PVM name for the architecture of the machine that you are currently running on (e.g. SUN4SOL2, SUNMP, or SUN4)

- Start the PVM daemon. If the installation instructions have been followed, a pvm alias should exist that facilitates starting the pvm daemon simply by typing *pvm*, followed by "quit" to return to the Unix prompt. (see Appendix C: More About PVM)
- Start RUNDMC by typing

rundmc <startup filename>

At this point, informational, warning, and error messages from RUNDMC, CAT, and GARP will appear on the screen. Processing takes time, so *be patient* ! Performance is obviously a function of the power and workload of the system on which CAT is being run; on a moderately loaded Sparc 20, processing 30 minutes of SAR data takes approximately 1 hour.

- Stop the pvm daemon by typing "pvm", followed by "halt".

2.4 CAT Output

CAT produces the following files:

- CAT output file: A binary file containing flight plan, track and complexity data, which can be examined interactively via CDAT (Complexity Data Analysis Tool). This file is named as specified by the CAT_OUTPUT_FILE parameter in the RUNDMC startup file.
- /direct/binrundmc.log : An ASCII log file containing various informational, warning, and error messages.
- /tmp/pvmd.NNN (where NNN is the Unix user number of the individual running CAT): An ascii log file containing information, warning, and error messages produced by the pvm daemon. This file is re-written each time the daemon is started, and typically doesn't contain any information useful for debugging CAT problems.
- /tmp/pvml.NNN (where NNN is the Unix user number of the individual running CAT): An ascii file produced by pvm that contains information, warning, and error messages produced by RUNDMC, CAT and GARP. (pvml.NNN captures anything written to *stdout* or *stderr* by processes running under pvm)

3. Complexity Data Analysis Tool (CDAT)

3.1 Overview

The Complexity Data Analysis Tool (CDAT, pronounced “see dat”) provides an interactive graphic environment for examining the complexity data produced by the Complexity Analysis Tool (CAT). CDAT can also play back track data extracted from System Analysis Recording (SAR) tapes. (see Figure 1-1 CAT / CDAT Overview)

The CDAT user interface consists of a primary window, a controls window, and miscellaneous pop-ups. Aircraft track and position data is displayed in the main viewing area of the primary window. The controls window contains miscellaneous control and display items. Complexity data is displayed in pop-up windows (one pop-up per sector).

CDAT plays back sector complexity and aircraft track and position data as a function of time. Controls are provided to start and stop playback, adjust the playback rate, and reposition the display to a specified time. (Note that the playback rate can be negative, in which case data is played in “reverse”.)

3.1.1 Primary Window

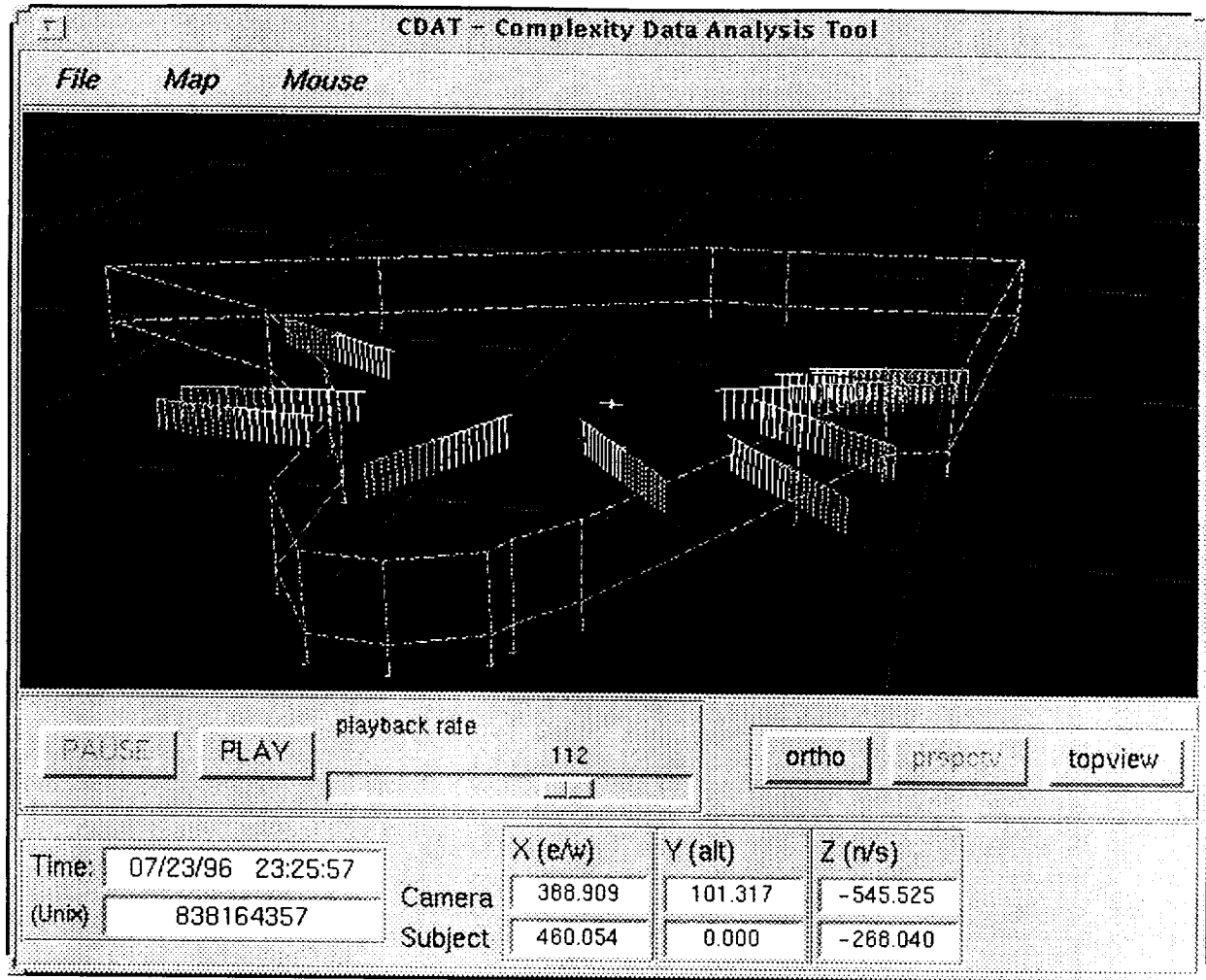


Figure 3-2 CDAT Primary Window

The primary window displays aircraft track and position data, and is comprised of the following items:

- *file menu*: provides functions for selecting playback files and exiting. (see 3.5 Loading a Playback File)
- *map menu*: provides functions for displaying airways, SIDs and STARs, and preferred routes. (see 3.7.4 Static Display Elements)
- *mouse menu*: provides functions for changing and displaying mouse settings. (see 3.7.1 Navigating in a 3d Scene: Moving the Camera / Subject)
- *main viewing area*: displays a 2d or 3d representation of aircraft track / position. (see 3.7 The Main Viewing Area)
- *playback controls*: provide controls for starting and stopping playback and adjusting playback rate. (see 3.6 Playing Back Data)

- *orthogonal* and *perspective* buttons: switch between orthogonal and perspective view transformations (for 3d rendering). (see 3.7.2 Perspective versus Orthogonal 3d View Transformations)
- *topview* button: automatically re-ori-ents the camera to provide a top-down north-up view. (see 3.7.3 Topview)
- *time* field: displays GMT time now, and can also be used to reposition the display to a specified time. (see 3.6.4 Time Reposition Function ... Goto Time X)
- *Unix* field: displays time now in Unix time, and like the *time* field, can also be used to reposition the display to a specified time. (see 3.6.4 Time Reposition Function ... Goto Time X)
- *camera / subject position* fields: display the current X-Y-Z position of the camera and subject. (see 3.7.1 Navigating in a 3d Scene: Moving the Camera / Subject)

3.1.2 Controls Window

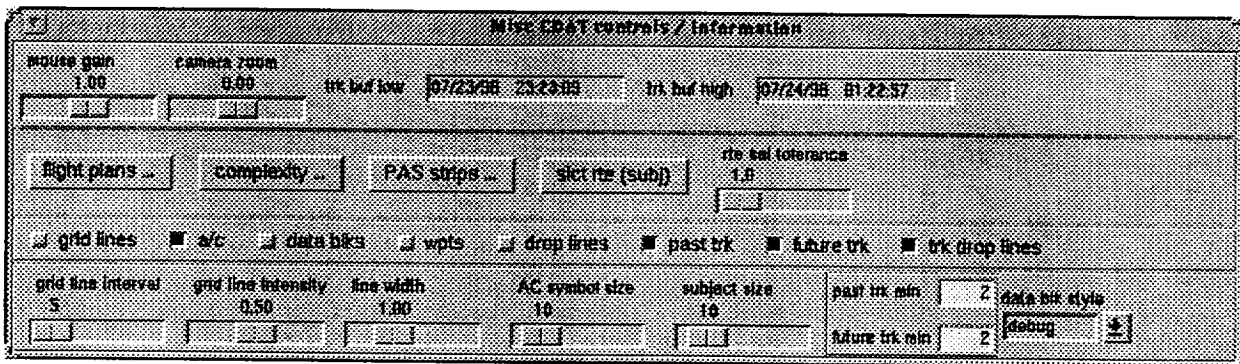


Figure 3-3 CDAT Controls Window

The controls window contains the following miscellaneous display and control items:

- *mouse gain* slider: adjusts the sensitivity of the mouse for camera / subject movement. (see 3.7.1 Navigating in a 3d Scene: Moving the Camera / Subject)
- *camera zoom* slider: adjusts the zoom level of the camera. (see 3.7.1 Navigating in a 3d Scene: Moving the Camera / Subject)
- *trk buf high* and *trk buf low* : display the starting and ending times of the track buffer. (see 3.6.1 The Track Buffer)
- *flight plans* button: displays flight plan data. (see 3.9.1 Dumping Flight Plan Data)
- *complexity* button: displays complexity data. (see 3.8 Displaying Complexity Data)
- *PAS strips* button: creates PAS strips. (see 3.9.2 Creating PAS Strips)
- *select rte (subj)* button: used (in conjunction with the *rte sel tolerance* slide) to view information for selected preferred routes. (see 3.9.3 Selecting / Dumping Preferred Routes)

- *grid lines, a/c, data blks, wpts, drop lines, past trk, future trk, and trk drop lines* check buttons: toggle the display of grid lines, aircraft symbols, data blocks, waypoints, a/c drop lines, past track data, future track data, and track drop lines respectively. (see 3.7.4 Static Display Elements)
- *grid line interval* and *grid line intensity* slides: control the distance between and display intensity of grid lines. (see 3.7.6.1 Grid Lines)
- *line width* slide: controls the width (i.e. thickness) of all line segments drawn in the main viewing area. (see 3.7.6.3 Line Width)
- *AC symbol size* and *subject size* slides: control the sizes of the aircraft and subject symbols. (see 3.7.5.1 A/C Symbols and 3.7.6.2 Subject Symbol)

3.2 CDAT Input

CDAT input files are of two types: system files and data input files.

3.2.1 System Files

System files are read once during system initialization, and contain static information (e.g. data defining SIDs and STARs, preferred routes, etc.). All system files reside in a single directory and are named as follows:

- *map*: contains map coordinate information specific to the ARTCC for which data is being analyzed
- *nfdc.apt*: contains NFDC airport data
- *nfdc.awy*: contains NFDC airway data
- *nfdc.fix*: contains NFDC fix data
- *nfdc.nav*: contains NFDC navaid data
- *nfdc.pfr*: contains NFDC preferred route data
- *nfdc.ssd*: contains NFDC data for SIDs and STARs
- *nfdc.sua*: contains NFDC data defining special use airspace (SUA)
- *sectors*: contains data defining sector boundaries

The majority of the system files are generic, i.e. not specific to the ARTCC for which data is being analyzed. Two of the files, however, are center-specific; the *map* file, and *sectors* file. To facilitate analyzing complexity and/or SAR data from different ARTCC's, upon invoking the tool, the user is given an opportunity to specify the path name of the system data directory to be used for the current CDAT session.

In a Unix environment, the system directory does not necessarily have to contain actual copies of the files listed above; instead, the system directory can contain links to the specific files that form a particular data set. The suggested method for maintaining multiple system directories, therefore, is to establish a master directory containing all of the system files, then create individual system directories consisting of links to the master directory for the specific files comprising a particular set.

For example, the master directory might contain *map* and *sector* files for both Denver and Los Angeles centers:

```
/CDAT/data/system_master/  
map.zdv
```

```
sectors.zdv
map.zla
sectors.zla
```

Center-specific system directories could then be created, one for Denver center, containing links to the generic nfdc files and the Denver-specific map and sector files in the master directory, the other for LA center, likewise containing links to the generic nfdc files and the LA-specific map and sector files in the master directory:

```
/CDAT/data/system_zdv/
map --> /CDAT/data/system_master/map.zdv
sectors --> /CDAT/data/system_master/sectors.zdv
nfdc.apf --> /CDAT/data/system_master/nfdc.apf
nfdc.awy --> /CDAT/data/system_master/nfdc.awy
etc.
```

```
/CDAT/data/system_zla/
map --> /CDAT/data/system_master/map.zla
sectors --> /CDAT/data/system_master/sectors.zla
nfdc.apf --> /CDAT/data/system_master/nfdc.apf
nfdc.awy --> /CDAT/data/system_master/nfdc.awy
etc.
```

Upon invocation of CDAT, selecting /CDAT/data/system_zla as the system directory would load all of the system files appropriate for analyzing SAR or complexity data from Los Angeles Center.

3.2.2 Input Data Files

CDAT can play back data from two types of files: complexity data files produced by CAT, and data files containing flight plan and track data extracted from SAR tapes.

Complexity files are binary files containing complexity, flight plan, and track data. (see 2.4 CAT Output) Such files are typically named with the extension ".cat.out", and can be selected via the File menu in the primary CDAT window. (see 3.5 Loading a Playback File)

SAR files are ASCII files containing flight plan and track data. Such files are typically created by running an extraction process on raw SAR data recorded at an Air Route Traffic Control Center. SAR files are commonly named with the extension ".sar_out", and may be selected via the File menu in the primary CDAT window. (see 3.5 Loading a Playback File)

3.3 CDAT Output

CDAT is an interactive user interface, providing a graphical environment for viewing flight plan, track, and complexity data. As such, CDAT's primary output is to the screen.

Each time a complexity file is selected for playback, CDAT automatically produces a master plot file containing the overall complexity for each sector. (The file is created in the directory from which CDAT was run, and is named *complexity.gnu_plot*.) This file is an ascii file, and may be used to plot overall sector complexity using the user's plotting tool of choice (e.g. gnu plot). (see Appendix D: Master Complexity Plot File)

3.4 Running CDAT

To run CDAT (in the Unix environment):

- Verify that path and LD_LIBRARY_PATH environment variables have been defined as described in the ACME Software Installation and Porting Guide.
- Change to the directory in which the CDAT executable is installed, (typically /direct/src/ui)
- Examine the CDAT file in this directory to verify that the DIRECT_ROOT variable has been properly defined. (If the installation procedures described in the ACME Installation and Porting Guide have been faithfully followed, no modifications to the CDAT file will be necessary.)
- Source the file CDAT in this directory ("source CDAT").
- Select an appropriate system data directory (see 3.2.1 System Files)

3.5 Loading a Playback File

Playback files are selected via the File menu in the primary CDAT window. CDAT supports two file selection methods: single file or list file.

To choose a single playback, select the

File / Playback File(s) / SAR (or CAT) / Pick Single File ...

menu option, and select the desired SAR (or CAT) playback file.

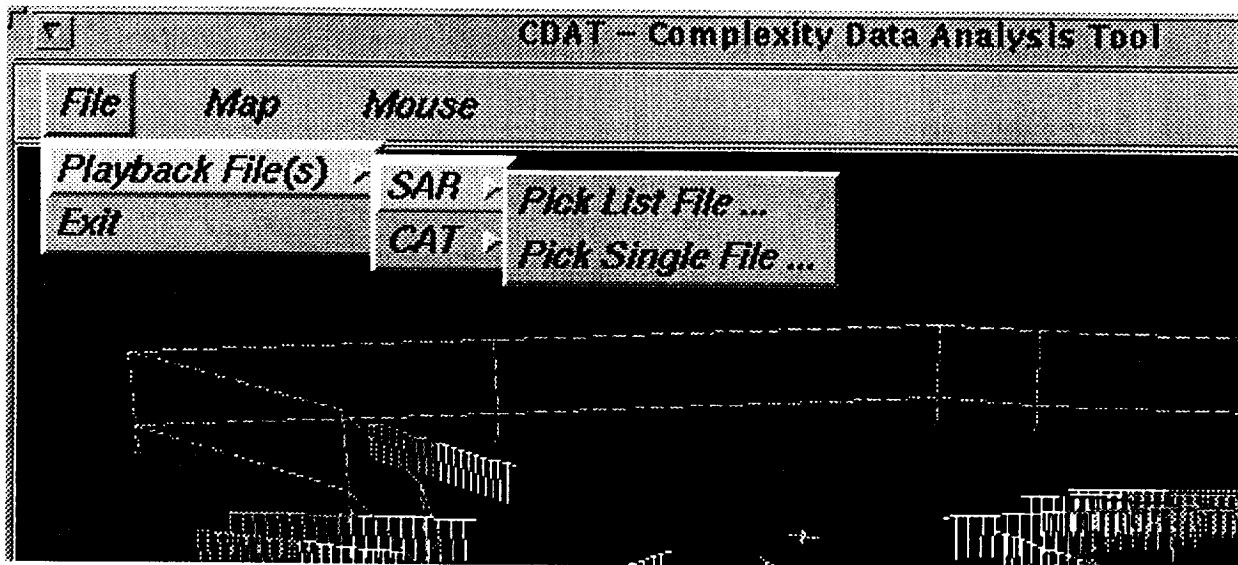


Figure 3-4 Loading a Playback File

To select multiple playback files, a "list" file must first be created which lists each of the SAR or CAT files to be loaded, in chronological order, one (full path) filename per line, left justified. (The default file extensions for SAR and CAT list files are .sar_list and .cat_list respectively.) Once created, list files may be selected via the

File / Playback File(s) / SAR (or CAT) / Pick List File ...

menu option.

3.6 Playing Back Data

3.6.1 The Track Buffer

For the sake of run-time performance, rather than playing data back directly from disk files, CDAT reads complexity and track data from disk into a structure in memory called the *track buffer*. CDAT data files can be very large, containing data for many aircraft over an extended period of time. Since computer memory is limited, rather than reading *all* of the data from a set of input files into the track buffer at once, only a finite number of track update points are read into memory. The track buffer is large enough to accommodate 600 track updates per aircraft; SAR data typically contains one track update every six seconds, so for a typical SAR file, the track buffer can hold $6 \times 600 = 3600$ seconds = 1 hour of data.

Initially, the track buffer is loaded with data from the beginning of the first file selected by the user. When playing data forward, the buffer is automatically re-loaded when the end of the buffer is reached. The buffer is also automatically re-loaded if the Goto Time X function is used to reposition the display to a time outside the current content of the buffer. (Note that when playing data in reverse (playback rate negative), the track buffer is *not* automatically reloaded when the beginning of the buffer is reached.)

The *trk buf low* and *trk buf high* fields in the controls window indicate the GMT time stamps of the first and last track updates contained in the buffer.

3.6.2 Play / Pause

The PLAY button starts playback, and is enabled once an input file has been selected.

The PAUSE button halts playback, and is only enabled when in PLAY mode.

3.6.3 Setting the Playback Rate

The *playback rate* slide in the controls window sets the playback rate. A playback rate of 1.0 yields data playback in real time. A playback rate of 2.0 plays data back twice as fast as real time, etc. The playback rate can be negative, in which case data is played in reverse.

Note that the rate at which the CDAT display can be updated is a function of the speed of the machine on which CDAT is running. However, the logic in CDAT which updates the display uses the system clock to determine how much *real* time has elapsed between successive screen updates, thereby taking into account variations in machine-dependent run time performance. For example, suppose two machines were placed side-by-side, both running CDAT, one machine powerful enough to support updating the display once per second, the other capable of updating the display only once every ten seconds. Provided the playback rate was set the same on both machines, as time passed, the reported position of a given aircraft would be identical on each machine.

3.6.4 Time Reposition Function ... Goto Time X

The display may be repositioned to a specified time simply by entering the desired time (*and hitting carriage return*) in either the GMT or Unix time field in the lower left hand corner of the primary display window. (see Figure 3-2 CDAT Primary Window) Note that time entry is enabled only in PAUSE mode.

If the time specified is contained in the track buffer, (i.e. the specified time is greater than *trk buf low* and less than *trk buf high*), then the display is repositioned to the specified time and the track buffer is not reloaded.

If the specified time is outside the range of the track buffer, then the track buffer is automatically reloaded starting at the specified time.

If the specified time precedes the first time in the selected input file(s), then the track buffer is reloaded starting with the first track update in the first data file, and an appropriate warning message is issued.

If the specified time is beyond the last track update in the selected input file(s), then the track buffer is reloaded with the last track update from the last input file, and an appropriate warning message is issued.

Hint: To quickly reposition to the beginning of a data set, type 0 (zero) in the Unix time field.

Hint: To force the track buffer to contain data surrounding (i.e. preceding and following) a specified time,

- determine how much time the track buffer can accommodate (typically one hour for SAR files)
- determine the time that would result in the *desired* time being roughly half way between the starting and ending track buffer limits (i.e. desired time minus one half of the total buffer time)
- force the buffer to reload by specifying a time *beyond* the desired time
- force the buffer to reload by specifying the target time calculated above
- reposition to the desired time (... this should *not* cause the buffer to reload)

At this point, the display should be positioned at the desired time, with roughly one half of the data in the buffer preceding the desired time, and one half of the data in the buffer following the desired time.

3.7 The Main Viewing Area

3.7.1 Navigating in a 3d Scene: Moving the Camera / Subject

CDAT maintains a three dimensional model of the world. The following concepts are important to understanding how to navigate in this model:

- *camera* - the position of the observer in CDAT's 3d model of the world, i.e. the vantage point from which a scene is observed.
- *subject* - the point in space at which the camera (i.e. the observer) is looking
- *field of view* - the extent to which the observer can see to the left or right of the subject, or more precisely, the angle subtended by the left and right planes of the viewing volume. In an actual camera, field of view is determined by the focal length of the lens; a "wide angle" lens has a wide field of view, while a telephoto lens has a narrow field of view. A zoom lens is constructed so that the focal length can be varied; thus "zooming" effectively changes the field of view.
- *viewing volume* - the volume of space observed by the observer. Viewing volume is determined by position of the observer (i.e. camera), the position of subject, and the field of view.
- *rendering* - rendering is essentially drawing, i.e. determining what line segments, polygons, and points to draw on a two dimensional screen to represent a three dimensional scene.

3.7.1.1 Moving the Camera and Subject

To navigate through the CDAT three dimensional world, the user uses the mouse to move the camera and/or the subject. Camera / Subject movement via the mouse is enabled via the *Mouse / Camera Movement* menu option in the primary CDAT window. The following table summarizes camera / subject movement:

	MB1	MB2	MB3
<nothing>	move camera left / right, backward / forward	<nothing>	move camera up / down
Shift	move subject left / right, forward / backward	<nothing>	move subject up / down
Control	move camera AND subject left / right, backward / forward	<nothing>	move camera AND subject up / down

In addition, the arrow keys may be used as follows:

	left / right arrow	up / down arrow
<nothing>	move camera left / right	move camera forward / backward
Shift	move subject left / right	move subject backward / forward
Control	move camera AND subject left / right	move camera and subject forward / backward

Lastly, the N, S, E, W, U, and D keys may be used as follows:

	n,s,e,w keys	u,d keys
<nothing>	move camera north/south/east/west	move camera up / down
Shift	move subject north/south/east/west	move subject up / down
Control	move both north/south/east/west	move both up / down

In addition, the camera and subject may be repositioned to an absolute XYZ coordinate by clicking in the Camera / Subject Position field of the Primary Window, typing in the desired coordinate value, and hitting carriage return.

3.7.1.2 Adjusting Mouse Sensitivity

The sensitivity of the mouse is a function of the distance between the camera and the subject; the farther away the subject is from the camera, the more sensitive the mouse is to movement, i.e. small movements in the mouse result in large changes in position of the camera / subject. Conversely, when the camera and subject are close to each other, mouse sensitivity decreases, and small movements in the mouse result in small changes in camera / subject position.

Mouse sensitivity can also be explicitly adjusted via the *mouse gain* slide in the controls window (see Figure 3-3 CDAT Controls Window)

3.7.1.3 Camera Zoom

The *camera zoom* slide in the controls window adjusts the zoom level of the camera, allowing the user to zoom in or out on a scene without repositioning the camera or the subject. Adjusting the camera zoom is a handy way to take a “quick look” at something up close, or zoom out to briefly examine a large area of a scene. However, zoom levels other than 0 introduce distortion, so for normal viewing, the camera zoom level should be 0.

3.7.2 Perspective versus Orthogonal 3d View Transformations

When a three dimensional scene is rendered, an orthogonal or perspective projection must be used.

- *perspective projection* - a mathematical projection for rendering a three dimensional scene that results in a “realistic” two dimensional drawing. In a scene rendered with a perspective projection, parallel lines converge at a vanishing point, and objects of the same size appear smaller when further away.
- *orthogonal projection* - in a scene rendered with an orthogonal projection, parallel lines appear parallel, and objects of the same size appear as the same size *regardless* of their distance from the observer.

The *perspective* button in the primary window selects a perspective projection for rendering. The *orthogonal* button selects an orthogonal projection. (see Figure 3-2 CDAT Primary Window)

3.7.3 Topview

The *topview* button in the primary window automatically places the camera directly above the subject, providing a top-down North-up view of the scene. (see Figure 3-2 CDAT Primary Window)

3.7.4 Static Display Elements

3.7.4.1 Airways

Airways may be displayed via the *Map / Airways* menu option in the primary window.

- *Select Airway by Name* allows the user to select airways for display by name.
- *Hide Selected Airways* removes the currently selected airways from the display.
- *Un-Hide Selected Airways* re-displays (previously selected) airways

Airways are displayed in red.

3.7.4.2 SIDs / STARs

Standard Instrument Departures (SIDs) and Standard Terminal Arrival Routes (STARs) may be displayed via the *Map / Sids & Stars* menu option in the primary window.

- *Show All Segments* displays all SIDs and STARs.
- *Hide All Segments* removes all SIDs and STARs from the display.

SIDs and STARs are displayed in blue.

3.7.4.3 Preferred Routes

Preferred routes may be displayed via the *Map / Preferred Routes* menu option in the primary window.

- *Show All* displays all preferred routes
- *Hide All* removes all preferred routes from the display
- *Show By Airport Pair* displays selected preferred routes.

Preferred routes are displayed in yellow.

3.7.4.4 Sector Boundaries

Sector boundaries are unconditionally displayed for all sectors defined in the sectors file. Sector boundaries are displayed in magenta.

3.7.4.5 Waypoints

Waypoint display is toggled on and off via the *waypoints* checkbox in the controls window. (see Figure 3-3 CDAT Controls Window) Note that in this version of CDAT, there is no mechanism for limiting the number of waypoints that are displayed, or selectively turning on / off waypoint identifiers.

Hint: Due to the overwhelming number of waypoints, unless the camera / subject position and zoom level are such that only a relatively small area of the earth's surface is visible in the main viewing area, the waypoint identifiers (which are displayed in white) will quickly blot out the scene, rendering it virtually useless.

3.7.5 Dynamic Display Elements

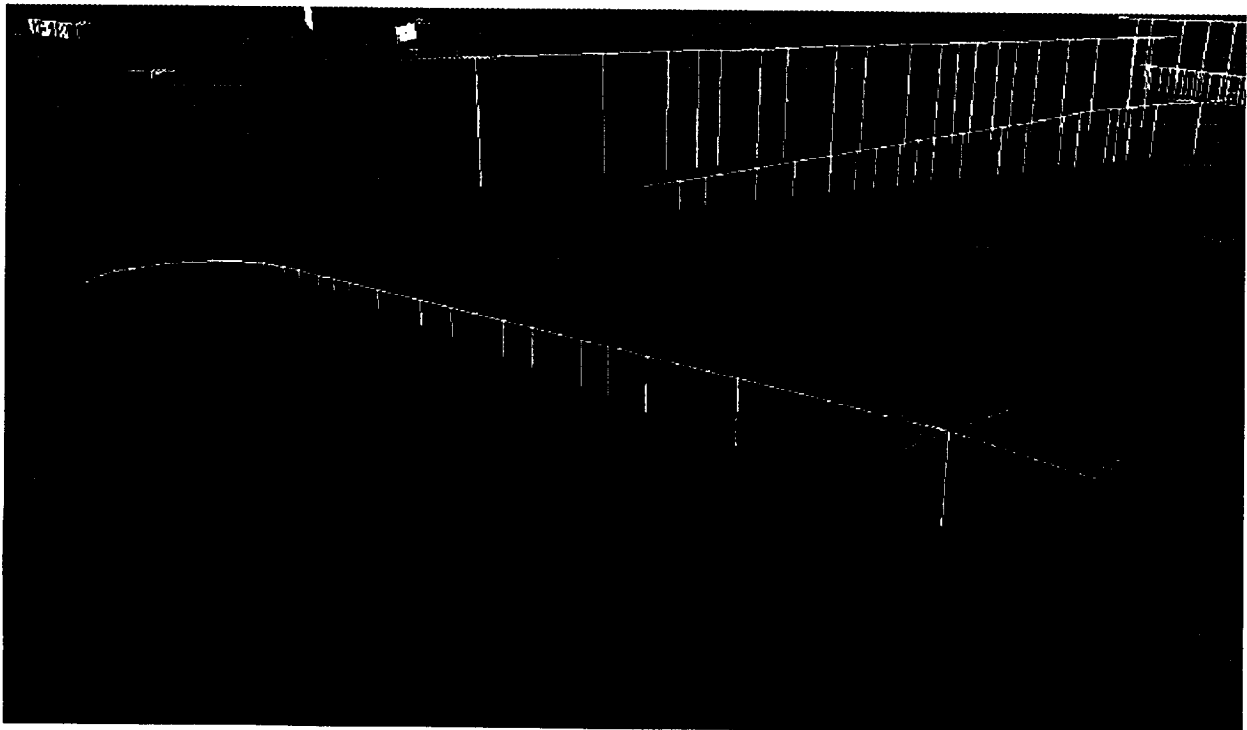


Figure 3-5 Aircraft, Drop Lines, Future / Past Track

3.7.5.1 A/C Symbols

The position of an aircraft is depicted by a "stick" airplane, complete with wings and a tail, displayed in cyan. Aircraft symbols may be toggled on / off via the *a/c* checkbox in the controls window. (see Figure 3-3 CDAT Controls Window) The size of the aircraft symbol may be adjusted using the *AC symbol size* slide in the controls window.

3.7.5.2 A/C Drop Lines

Drop lines are used to indicate the altitude of an aircraft. Drop lines may be toggled on / off via the drop lines checkbox in the controls window. (see Figure 3-3 CDAT Controls Window) If the altitude contained in the input file is a mode C altitude, then the drop line is displayed in cyan. If the mode C altitude is not available, the assigned altitude from the flight plan is used, and the drop line is displayed in red.

3.7.5.3 Past / Future Track

Past and future track may be toggled on / off via the *past trk* and *future trk* checkboxes in the controls window. (see Figure 3-3 CDAT Controls Window) The number of minutes of past / future track data displayed via the *past trk min* and *future trk min* entry fields in the controls window.

Past track is displayed in cyan. Future track is displayed in white.

3.7.5.4 Track Drop Lines

Track drop lines (indicating the altitude of the aircraft at each track point) may be toggled on / off via the *trk drop lines* checkbox in the controls window. (see Figure 3-3 CDAT Controls Window) If the altitude contained in the input file is a mode C altitude, then past track drop lines are displayed in cyan, and future track drop lines are displayed in white. Otherwise, the assigned altitude from the flight plan is used, and the track drop line is displayed in red.

3.7.5.5 Data Blocks

Data blocks may be toggled on / off via the *data blks* checkbox in the controls window. (see Figure 3-3 CDAT Controls Window) There are three available styles of data blocks, selectable via the *data blk style* entry in the controls window:

- *debug*: data block contains the aircraft identifier, cid, flight level, ground speed, X coordinate, Y coordinate, and heading.
- *full*: data block contains the aircraft identifier, flight level, and ground speed.
- *limited*: data block contains the aircraft identifier and flight level.

3.7.6 Miscellaneous Display Elements / Controls

3.7.6.1 Grid Lines

Grid lines are lines drawn at ground level, oriented North-South and East-West to form a grid pattern. The following controls can be used to manipulate the display of grid lines: (see Figure 3-3 CDAT Controls Window)

- *grid lines* checkbox: toggles grid lines on / off
- *grid line interval* slide: adjusts the distance (in nautical miles) between grid lines
- *grid line intensity* slide: adjusts grid line brightness

3.7.6.2 Subject Symbol

The position of the subject is indicated by a gold six-pointed star, with a drop line and red compass needle (drawn at ground level, pointing North). (Note that the altitude of the subject can be independently controlled ... in Figure 3-7 Subject Symbol, the subject's altitude is non-zero, while in Figure 3-6 Subject Symbol, the subject's altitude is zero, i.e. the camera is looking at a point on the ground.)

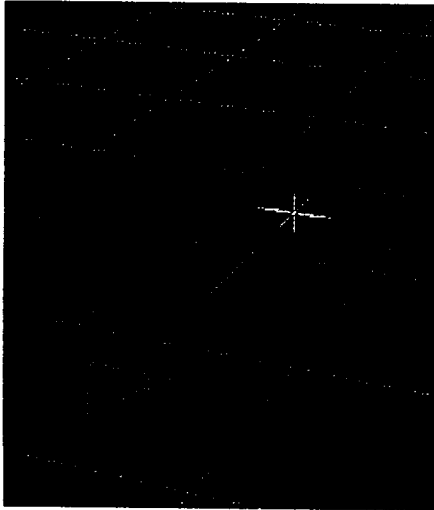


Figure 3-6 Subject Symbol

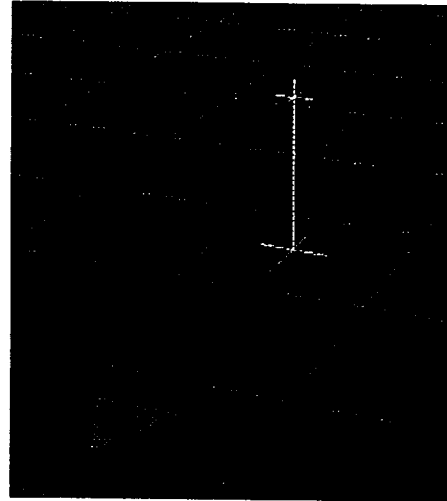


Figure 3-7 Subject Symbol

The size of the subject symbol can be adjusted via the *subject size* slide in the controls window. (see Figure 3-3 CDAT Controls Window) Note that the subject size can be set to zero, effectively eliminating the subject symbol from the display.

3.7.6.3 Line Width

The line width (i.e. thickness) of line segments drawn in the main viewing area can be adjusted via the line width slide in the controls window. (see Figure 3-3 CDAT Controls Window)

3.8 Displaying Complexity Data

Complexity data for a sector is displayed in a pop-up window, raised via the *complexity* button in the controls window. (see Figure 3-3 CDAT Controls Window)

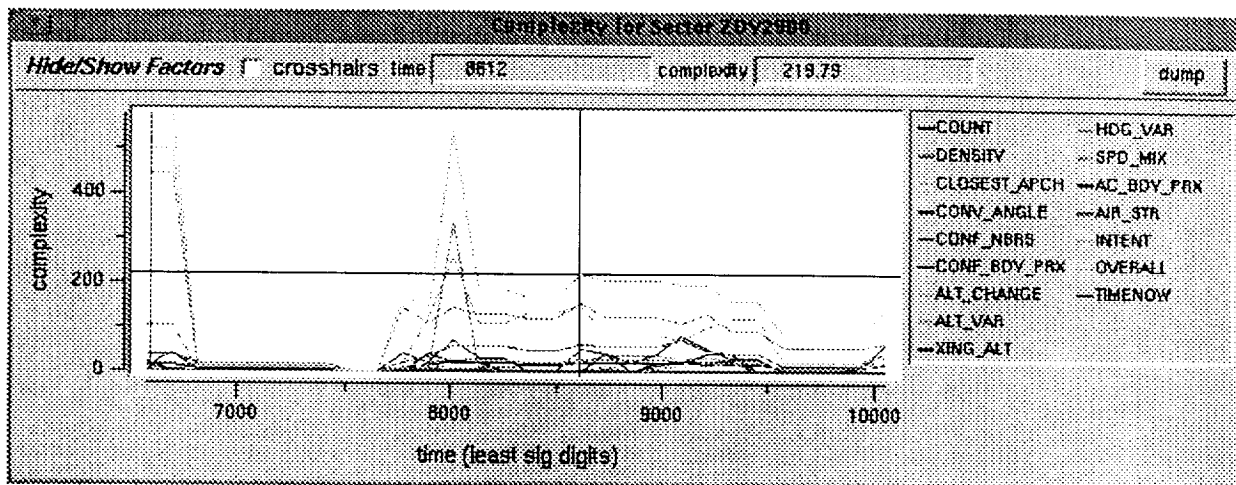


Figure 3-8 Complexity Pop-Up

Each complexity pop-up contains a two dimensional plot of complexity as a function of time. The time axis is labeled with the least significant digits of the Unix time; *time now* is indicated by a vertical line drawn in red. Both overall and individual complexity factors appear in the graph, each plotted in a different color (as indicated by the legend in the right side of the pop-up). The *Hide / Show Factors* menu is used to toggle the display of individual factors. (see below)

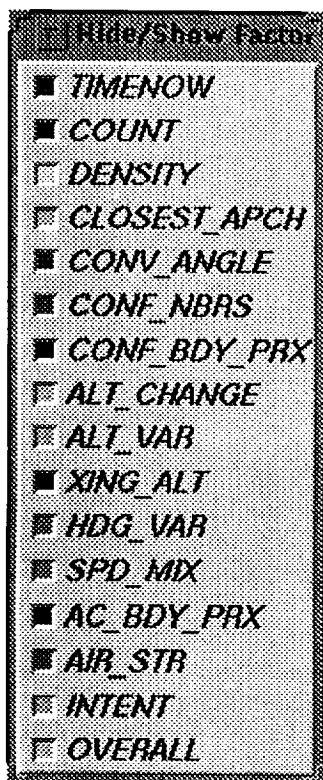


Figure 3-9 Hide / Show Factors Menu

The *cross hairs* button toggles the display of cross hairs, which can be used to determine the precise time / complexity values for a given point on the graph.

The *dump* button dumps (tabular) complexity data to the window in which CDAT was originally invoked.

Hint: The *Hide / Show Factors* menu is a tear-off menu; a horizontal dashed line appears in the menu immediately above the first menu item. Releasing the cursor on this dashed line tears the menu off, creating a separate window containing the menu itself. Using the tear-off feature generally makes it much easier to quickly toggle on / off selected complexity factors.

Hint: Complexity plots are auto-scaled, based on the largest X/Y values present in the data currently being displayed. If one (or more) of the individual factors in a complexity plot peak out at a value much larger than any of the other factors, auto-scaling can cause the other factors to "flat line". If this appears to be the case, use the *Hide / Show Factors* menu to hide *Time Now*, (which by definition takes on the maximum Y value present in all of the individual factors), and then successively hide the largest remaining factor to progressively reveal more detail in each of the lesser factors.

3.9 Miscellaneous Functions

3.9.1 Dumping Flight Plan Data

The *flight plans* button in the controls window raises a selection pop-up containing the CID's (computer id's from the host) for all of the aircraft present in the currently loaded data file(s). Selecting (i.e. double clicking) on a CID causes the flight plan data for the selected CID to be dumped to the screen in the window from which CDAT was originally invoked.

3.9.2 Creating PAS Strips

Selecting the *PAS Strips* button in the controls window raises the pop-up pictured below.

PAS strips may be dumped to the screen (in the window from which CDAT was originally invoked), or to a file. The controls present in the PAS strip selection pop-up have the following affect:

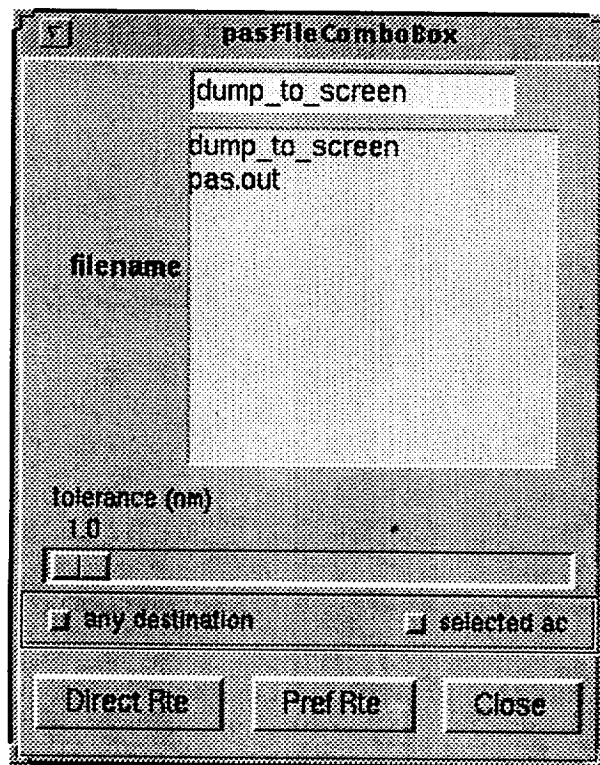


Figure 3-10 PAS Strips ...

- *Direct Route* button: generates PAS strips for the direct route from the current aircraft position to the filed destination.

- *Pref Route* button: generates PAS strips along the first preferred route located in the preferred routes file that (a) passes within *tolerance* nautical miles of the aircraft's current position and (b) terminates at the filed destination, or any destination, depending on the status of the *any destination* checkbox.
- *selected ac* checkbox: If selected, PAS strips are generated only for selected aircraft; otherwise, PAS strips are generated for ALL aircraft. To select specific aircraft, choose the Select A/C option of the Mouse menu in the Primary Window. Having done so, A/C may be selected / deselected using MB1 in the main view area. Selected aircraft are displayed in magenta.

3.9.3 Selecting / Dumping Preferred Routes

The *select rte (subj)* button in the controls window can be used to dump preferred route information to the screen for the first route found in the preferred routes file that passes within *rte sel tolerance* nautical miles of the current position of the subject. (see Figure 3-3 CDAT Controls Window)

Appendix A: SAR Input File Format

A SAR input file is an ascii file consisting of a one line header, followed by flight plan and track "messages", one message per line. The file may contain comments; a comment is defined as any line beginning with a pound sign (#) in column 1.

Below is an example SAR input file. Detailed explanations of each follow.

```
802447810 ZCD Reel 12 (GMT Start Time: Tue Jun 6 15:10:10 1995)
# begin carry-over flight plans
0 151010.5 FP FDX3602 DC10/R 1 3217 485 RLG116010 1448 33000 OAK./DR..MKC.J80.VHP..IND/1645 2
0 151010.5 FP UAL187 DC10/R 3 2711 498 DEN 1502 35000 DEN..JNC.J80.OAL.MOD2.SFO/1721 3
0 151010.5 FP ASH221 BE02/R 4 2634 260 TAS 1523 22000 SAF./TAS..ALS.LARKS1.DEN/1625 2
.
.
.
# end carry-over flight plans
5 151016.0 TK G40484 733 24000 536.5 581.0 250 247
5 151016.0 TK N414MJ 541 14000 310.6 484.3 163 267
5 151016.0 TK ASH7472 710 24000 458.9 462.2 283 350
7 151017.5 RS SCANDL1 11
7 151017.5 AM AAL33 DC10/R 232 2735 489 GCK267041 1518 35000 JFK./SZLR..TBC.J64.CIVET.CIVET1.LAX/1733 2
10 151020.5 FP AAL1379 MD80/R 328 2202 458 GCK237051 1600 31000 DFW./ADM.J52.LAA.QUAIL1.DEN/1634 2
11 151022.0 TK G40484 733 24000 536.2 580.8 249 246
.
.
.
```

Header: The header must appear as the first line in the file, and contains the Unix start time (the number of seconds that have elapsed since January 1, 1970), the SAR tape Reel Number, and the GMT start time.

Carry Over Flight Plans: The first flight plan messages appearing in the file are flight plans that were "carried over" from a preceding file, i.e. the flight plans existed in the ARTCC host system prior to the start time of this file. All such flight plans have a relative time stamp of zero. The block of carry over flight plans is preceded by the comment "# begin carry over flight plans", and followed by the comment "# end carry over flight plans".

Common Fields: All messages in a SAR file begin with the following four fields:

- relative time stamp: an integer number indicating how many seconds have elapsed since the beginning of the file.
- absolute time stamp: a floating point number indicating the 24 GMT time of day, in the format HHMMSS.n where HH = hours, MM = minutes, SS = seconds, and .n is tenths of seconds.
- message type: FP = flight plan, AM = flight plan amendment, RS = remove strip, TK = track, UT = unknown track.
- aircraft id: ascii aircraft identifier

Flight Plan Message (FP): A flight plan message is published when a flight plan is first introduced in the ARTCC host system, and consists of the following fields:

- relative time stamp, absolute time stamp, message type = FP, aircraft id
- aircraft type/equipment designator (e.g. DC10/R)
- cid (ARTCC host computer id), e.g. 3
- 4 digit beacon code (e.g. 3217)
- filed air speed in knots (e.g. 485)
- coordination fix id (e.g. DEN)

- coordination time in HHMM (e.g. 1502)
- assigned altitude in feet (e.g. 35000)
- filed route (e.g. DEN..JNC.J80.OAL.MOD2.SFO/1721)
- status field (1=proposed 2=active 3=active departure)

Flight Plan Amendment (AM): This message is published when the ARTCC host receives a flight plan amendment, and has the same format as the flight plan message, except for the message type, which is "AM".

Remove Strip Message (RS): This message is published when a flight plan is removed from the ARTCC host, and consists of the following fields:

- relative time stamp, absolute time stamp, message type = RS, aircraft id
- cid (ARTCC host computer id), e.g. 3

Track Message (TK), Unknown Track Message (UT): Track and unknown track messages are published once every six seconds for each airplane being tracked by the ARTCC host. An "unknown" track message is for an aircraft that is being tracked by the host, but for which the host has no flight plan data. TK and UT messages consist of the following fields:

- relative time stamp, absolute time stamp, message type = TK (or UT), aircraft id
- cid (ARTCC host computer id), e.g. 733
- altitude in feet; (e.g. 24000). Note that mode c altitude is typically not available for the first few radar sweeps, in which case the assigned altitude from the flight plan is used, and is preceded by a capital "A" (e.g. A24000).
- X coordinate in ARTCC coordinate, units = nautical miles (e.g. 536.5)
- Y coordinate
- ground speed in nm/hour (e.g. 250)
- heading in degrees magnetic (e.g. 247)

Appendix B: RUNDMC Startup Files

The following is an example RUNDMC startup file:

```
#
#      Copyright (c) 1995 Wyndemere Incorporated
#      All Rights Reserved -- @(#)rundmc.startup 1.1 31 Jan 1996
#
# path to executables
RUNDMC_EXECUTABLE    /direct/bin/SUN4SOL2/rundmc
GARP_EXECUTABLE      /direct/bin/SUN4SOL2/garp -p
CAT_EXECUTABLE       /direct/bin/SUN4SOL2/cat
#UI_EXECUTABLE       /direct/bin/SUN4SOL2/ui

# hosts (not implemented yet, i.e. the HOST values are ignored, but must be in the file)
RUNDMC_HOST    swift
GARP_HOST      swift
CAT_HOST       swift
UI_HOST        swift

# execution directories for each process
RUNDMC_EXEC_DIR    /direct/bin/
GARP_EXEC_DIR      /direct/bin/
CAT_EXEC_DIR       /direct/bin/

# data directories
CTAS_DATA_DIR      /direct/data/
NFDC_DATA_DIR      /direct/data/system/

CAT_OUTPUT_FILE     /direct/data/input/ZDV.ff.cat.out

# analysis request parameters
AIRPORT_ID          DEN
CENTER_ID           ZDV
INPUT_DATA_FILENAME /direct/bin/SUN4SOL2/ZDV.list
SECTOR_LIST_FILENAME xxx

# INPUT_MODE options are INPUT_FILE and INPUT_LIST
INPUT_MODE          INPUT_LIST

OUTPUT_TIME_STEP    15
COMPLEXITY_TIME_HORIZON 15

# ROUTE_PROCEDURE options are FULL_FREE_FLIGHT, HALF_FREE_FLIGHT, CURRENT
ROUTE_PROCEDURE     FULL_FREE_FLIGHT

# ROUTE_LENGTH options are DEPT_DEST and COORD_FIX_TO_DEST
ROUTE_LENGTH        DEPT_DEST
```

The file can contain blank lines and comments (lines beginning with #). Fields in this file control the execution of the complexity analysis tool as follows:

- **xxx_EXECUTABLE:** provide the path name to the executables for each process. Note that the path specified for UI (the user interface) has no affect, and hence, is commented out. This field typically does not change once the ACME software has been installed.
- **xxx_EXEC_DIR:** specifies the directory from which each process will execute. This field typically does not change once the ACME software has been installed.

- CTAS_DATA_DIR: specifies the location of CTAS related data for trajectory generation (typically /direct/data) This field typically does not change once the ACME software has been installed.
- NFDC_DATA_DIR: specifies the location of NFDC and NAS data, typically /direct/data/system. This field typically does not change once the ACME software has been installed.
- CAT_OUTPUT_FILE: specifies the name of the output file that CAT creates.
- INPUT_DATA_FILENAME: specifies the name of the input file, which is either a single SAR file, or a file containing a LIST of SAR files, depending on the value of INPUT_MODE.
- INPUT_MODE: Can be either INPUT_FILE, in which case INPUT_DATA_FILENAME is the name of a single SAR input file, or INPUT_LIST, in which INPUT_DATA_FILENAME is the name of a file containing a list of SAR input files, one (full path) filename per line, left justified.
- ROUTE_PROCEDURE: Determines what kind of route GARP generates and how much significance CAT assigns to "knowledge of intent"; can be one of the following values:
 - CURRENT : GARP generates a route based on the preferred route from the filed origin (or coordination fix, based on the value of ROUTE_LENGTH) to the filed destination.
 - HALF_FREE_FLIGHT: GARP generates a direct route from the filed origin (or coordination fix, based on the value of ROUTE_LENGTH) to the filed destination.
 - FULL_FREE_FLIGHT: GARP generated a direct route from the filed origin (or coordination fix, based on the value of ROUTE_LENGTH) to the filed destination. In addition, CAT assigns more significance to the complexity contributed by "knowledge of intent" in FULL versus HALF free flight.
- ROUTE_LENGTH: Determines whether GARP generates a route from the filed origin to the destination (DEPT_DEST), or from the coordination fix to the destination (COORD_FIX_TO_DEST).

The following fields are present in the example file, but are currently not used: UI_EXECUTABLE, xxx_HOST, AIRPORT_ID, CENTER_ID, SECTOR_LIST_FILENAME, OUTPUT_STEP, COMPLEXITY_TIME_HORIZON.

Appendix C: More About PVM

PVM (Parallel Virtual Machine) is a public domain interprocess communication package utilized by ACME. Documentation is available at the ftp site referenced in the ACME Software Installation and Porting Guide.

In brief, to use PVM, the user must start a pvm "daemon". If the procedures outlined in the ACME Installation and Porting Guide have been followed, a pvm alias should exist that invokes the pvm console, an interactive command oriented pvm user interface. Bringing up the pvm console automatically starts the pvm daemon. Typing "quit" from the console exits the console, but leaves the daemon running. Typing "halt" from the console kills the daemon and exits the console.

Note that ACME does not automatically kill the pvm daemon upon completion. The user must re-enter the pvm console, and type "halt" to kill the daemon.

Appendix D: Master Complexity Plot File

Each time a CAT output file is loaded into CDAT, CDAT produces a file containing overall sector complexity named *complexity.gnu_plot* in the directory from which CDAT was run (typically /direct/src/ui). This file is an ascii file containing complexity data for each sector, and can be used for plotting overall complexity using the user's plotting tool of choice (e.g. *gnu_plot*).

Below is an excerpt from *complexity.gnu_plot* indicating how the file is formatted. The first column contains the sector name, the second, the Unix time stamp (i.e. the GMT time expressed as the number of seconds that have elapsed since Jan. 1, 1970), and the third, the overall complexity rating.

```
ZDV08 802444733 0.000000
ZDV09 802444733 0.943413
ZDV08 802444854 1.258246
ZDV09 802444854 0.943413
ZDV08 802444974 3.342330
ZDV09 802444974 0.862313
ZDV08 802445098 3.645823
ZDV09 802445098 0.781213
```

```
.
.
.
```